Net Savings Estimation in Appliance Recycling Programs: A Review and Empirical Analysis with Recent California Data

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Abstract

The net-to-gross (NTG) ratio has a powerful but often poorly understood influence on the overall savings impacts of energy efficiency programs in general and appliance turn-in programs in particular. In California, KEMA, Inc. (previously XENERGY) developed an influential general approach to estimating net savings for appliance recycling programs. This paper addresses issues related to using that approach for the estimation of net savings for appliance recycling programs. Historical and recently developed data collected for an evaluation of appliance recycling programs in California have been used to examine the approach. These survey data were used to replicate, supplement, and re-evaluate the approach developed by KEMA for estimating net savings. The expanded sample sizes for non-participants as well as participants have been used to analyze inter-utility and participation mode (primary, secondary refrigerator, or freezer) variations in NTG ratios.

Introduction

California's history with appliance recycling programs extends to the late 1970s, when Pacific Gas and Electric (PG&E) partnered with the Salvation Army to start the first refrigerator recycling program. That program ran for several years until PG&E discontinued it the 1980s. Southern California Edison (SCE) began an appliance recycling program in 1993 and ran the program with modifications, until 2002. A Statewide Residential Appliance Recycling Program (RARP) began in 2002 as a statewide extension of SCE's program.

The purpose of the Statewide RARP is to remove working but inefficient refrigerators (both primary and secondary) and freezers from utility distribution systems. The program is available to eligible customers on a first-come first-served basis in the service territories of the California Investor Owned Utilities (IOUs): PG&E, SCE, and San Diego Gas and Electric (SDG&E). Each utility manages its own program while adhering to agreed-upon common elements.

An important element of the evaluation of the Statewide RARP is to determine the net savings being realized with the program. Refrigerators that were removed by the program might have been disposed of in a way that would have resulted in their removal from the electric grid without the program. Thus the question is, what proportion of gross savings resulting from the removal of refrigerators is attributable to the RARP.

Numerous prior studies have examined this question. Table 1 shows the estimates of the net-to-gross (NTG) ratios that have been estimated for California refrigerator recycling programs (using somewhat different methods). As can be seen, the NTG estimate for the 2002 Statewide RARP is the lowest.

Table 1. *Estimates of NTG Ratios for Refrigerators in Studies Evaluating California Appliance Recycling Programs*

Study	***Estimated NTG Ratio for Refrigerators***
Impact Evaluation of 1994 Spare Refrigerator Recycling Program, Project ID 515, Final Report to SCE, Xenergy, 1996	0.423
Impact Evaluation of the Spare Refrigerator Recycling Program, CEC Study #537, Final Report to SCE, Xenergy, 1998	0.53
Measurement and Evaluation Study of 2002 Statewide Residential Appliance Recycling Program, Final Report, KEMA-Xenergy, 2004	0.35
Measurement and Verification Report for NCPA SB5X Refrigerator Recycling, Final Report, Robert Mowris & Associates, 2003	0.64
Measurement and Verification of SB5X Energy Efficiency Programs for the Sacramento Municipal Utility District, Final Report, Heschong Mahone Group, 2003	0.55

Free-riderhsip for appliance turn-in programs in other states have also been evaluated in recent studies.

- In an evaluation of the appliance retirement program in Connecticut, Nexus Market Research estimated that program free-ridership for refrigerators was about 16%.
- In an analysis of the free-ridership rate for the Residential Appliance Turn-In Program in Wisconsin, PA Consulting Group estimated the range for program free-ridership to fall between 45% and 69%, with a midpoint of 57%.

As these citations show, there is a wide range in the estimates of NTG ratios and of free-ridership rates for appliance retirement programs. The purpose of this paper then is to provide a review of net savings estimation for appliance recycling programs using data from evaluation of the Statewide Residential Appliance Recycling Program (RARP) in California. The discussion begins with a description of the method used to estimate net impacts for the 2002 Statewide RARP. The assumptions are examined and alternative assumptions applied to see how the net-to-gross ratio is affected. In particular, the method is applied using larger samples from the 2004-2005 Statewide RARP evaluation. An alternative approach for addressing net program impacts is presented that primarily addresses the issue of program free-ridership.

Review of Approach to NTG Analysis for 2002 Statewide RARP

The evaluation of the 2002 Statewide RARP was conducted by KEMA-Xenergy, Inc. (KEMA). KEMA used a method for the net-to-gross analysis that has two main components: *attribution* factors and *part use* factors. As described in KEMA's report: "The attribution factor adjusts for the percentage of participants that would have disposed of the unit anyway, and gives partial credit to the program for destroying a unit that would otherwise have been transferred to another user. The part-use factor adjusts for the fraction of the time that participants would have used the unit if they had kept it."[1]

The goal of California's Statewide RARP is to prevent the continued use of inefficient used units in the service territories of SCE, PG&E, and SDG&E. The program focuses on the "recycled unit" as the treated entity and not on the household. Accordingly, the net-to-gross analysis pertains to what

[1] KEMA-XENERGY, Inc. *Final Report: Measurement and Evaluation Study of 2002 Statewide Residential Appliance Recycling Program,* Prepared for Southern California Edison, February 2004.

would have happened to an appliance unit recycled through RARP if it had not been recycled. There are four possible outcomes for a unit that is not recycled. These outcomes are:

- Unit is kept by the household but not used;
- Unit is kept by the household and still used;
- Unit is discarded by the household through a disposal method in which the unit would be destroyed; and
- Unit is discarded by the household through a disposal method in which the unit would be transferred and kept in use.

Table 2 illustrates the calculation of the overall net to gross ratio for refrigerators in KEMA's evaluation of the 2002 RARP. Using the "kept in use" outcome to illustrate the calculation, nine percent of households say that they would have kept the unit and used it 88 percent of the time (.09 x 1.0 x 0.88= 0.079). Summing across the categories results in the overall net-to-gross ratio. The estimated net to gross ratio of 0.35 is lower than for evaluations of other refrigerator recycling programs and lower than KEMA's previous estimate for the evaluation of a similar program in SCE territory

Table 2. *Calculation of Overall NTG Ratio for Refrigerators per KEMA Approach for Evaluation of 2002 RARP*

What Would Have Happened to Recycled Unit	***Percentage of Units in Category***	***Attribution Factor for Category***	***Part Use Factor***	***PxAxU***
Kept but not used	4.60%	1.000	0.000	0.000
Kept, in use	9.00%	1.000	0.880	0.079
Discarded-Destroyed	21.43%	0.000	0.000	0.000
Discarded-Transferred	64.97%	0.429	0.977	0.272
Overall net to gross ratio				0.351

KEMA calculated the percentages in Column 2 of Table 2 using data collected from several surveys.

- Data from a survey of 390 program participants were used to determine the percentage of units that would have been kept and the percentage that would have been discarded if they had not disposed of through the RARP. For the 390 participants, 18 (4.6%) would have kept but not used the unit, 35 (9.0%) would have kept the unit in use, and 337 (86.4%) would have discarded the unit some other way.
- Responses from a survey of 133 recent non-participant discarders of appliances provided data on the proportions of discarded refrigerators or freezers that would be destroyed or that would be transferred through sale, gift, donation, etc. Based on data obtained from this survey, it was determined that 24.8% of the discarded units would have been destroyed and 75.2% would have been transferred. (Multiplying these percentages by 86.4% gives the percentages reported for the discarded-destroyed and discarded-transferred categories in Table 2.

Each of the four categories was assigned an attribution factor that specifies the gross savings from recycled units that should be credited to RARP, expressed as a percentage of the average energy use of the units recycled through RARP. For three of the categories (i.e., kept in used, kept but not used, discarded-destroyed), the assigning of the attribution factor is relatively straightforward.

- For a unit that would otherwise have been kept in place (either used or not), the program receives full credit for the savings associated with the removal of such units. The attribution factor is assigned a value of 1.

- For a discarded unit that would otherwise have been destroyed, the program receives no credit for savings because such units would have been destroyed (removed from the grid) without the program. The attribution factor is assigned a value of 0.

The discarded-transferred category includes those units whose transfers to other parties were precluded because of RARP. In 2002 KEMA used a survey of 77 recent acquirers of used refrigerators for the discarded-transferred category attribution factors. Attribution factors were assigned based on what these acquirers of used units would have done when the acquired unit was not available as a basis to adjust for what would have happened to the recycled units in the absence of the program.

Table 3 shows the values that KEMA assigned for the attribution factors for eight different cases, defined by (1) whether the unit would be used as a main or a spare unit and (2) what transferees would do because recycling made a unit not available. For cases where a new unit would have been bought, the attribution factor was computed as the difference in annual energy use (UEC) between a new unit and the average unit picked up by the program, expressed as a fraction of the program's average UEC.

The overall attribution factor for the discarded-transferred category was determined as a weighted average of the attribution values in Table 3, where the weights are determined by the percentage distribution of units in the discarded-transferred category across the eight cases. As can be seen, the calculated attribution factor for the discarded-transferred category is 0.429.

Table 3. *Calculation of Attribution Factor for Refrigerators in Discarded-Transferred Category Using Data from Evaluation of 2002 RARP*

Main or Spare Unii	*What Would Transferee Do Because Recycling Made Unit Not Available?*	*Sample n*	*Percent of Total N*	*Attribution Factor*	*Weight x Attribution Factor*
Main	Buy a new unit	26	33.8%	0.70	0.236
Main	Buy/fix similar used unit	27	35.1%	0.00	0.000
Main	Buy worse used unit	4	5.2%	0.00	0.000
Main	Not buy another unit	5	6.5%	1.00	0.065
Spare	Buy a new unit	4	5.2%	0.70	0.036
Spare	Buy/fix similar used unit	3	3.9%	0.00	0.000
Spare	Buy worse used unit	1	1.3%	0.00	0.000
Spare	Not buy another unit	7	9.1%	1.00	0.091
Totals		77	100.0%		0.429

In KEMA's approach, part-use factors are used to adjust for the fraction of the time that participants would have used a recycled unit if they had kept it. Different values for the part use factors were assigned to the four categories into which recycled units would fall if they had not been recycled.

- For units that would have been kept but not used or that would have been destroyed when discarded, the part use factor is 0. That is, even if not recycled, it was assumed that these units would have no energy use.
- For units that would have been kept and used by households, KEMA assumed the units would have been used as secondary refrigerators. Using a survey of participants who disposed of a secondary refrigerator, the part-use value was calculated as the average of the months in the year that the unit was said to be plugged in and running divided by12 (months in the year). This average was determined to be 0.88.
- For units in the discarded-transferred category, the part use factor was calculated as a weighted average of two part use values: a part use factor of 1.0 for main refrigerators and of 0.88 for spare refrigerators. From Table 3, main refrigerators were estimated to represent

80.6% of this category and spare refrigerators 19.4%. Thus, the weighted part use factor for the discarded-transferred category was calculated to be .977.

Applying KEMA Approach to NTG Analysis for Evaluation of 2004-2005 Statewide RARP

Using updated data from recent surveys of participants and non-participants the NTG ratio was calculated for the 2004-2005 Statewide RARP. The overall value of .409 (Table 4) is somewhat higher than the value of 0.351 that KEMA calculated for the 2002 RARP evaluation. This somewhat higher NTG ratio is attributable to a higher attribution value for the discarded-transferred category and somewhat higher part-use values.

Table 4. *Overall Net-to-Gross Ratio Calculated with KEMA Approach for Refrigerators Recycled through 2004-2005 Statewide RARP*

What Would Have Happened to Recycled Refrigerator	***Percentage of Refrigerators in Category***	***Attribution Factor for Category***	***Part Use Factor***	***NTG PxAxU***
Kept but not used	4.1%	1.000	0.00	0.000
Kept, in use	12.0%	1.000	0.923	0.111
Discarded-Destroyed	25.8%	0.000	0.00	0.000
Discarded-Transferred	58.1%	0.520	0.988	0.298
Overall net to gross ratio				0.409

The percentages in Column 2 of Table 4 were estimated using data collected from several surveys:

- Data from a survey of 716 participants in the 2004-2005 Statewide RARP were used to determine the percentage of refrigerators that would have been kept and the percentage that would have been discarded if they had not disposed of through the RARP. Using these data, the percentage who would have kept but not used the refrigerator was estimated to be 4.1%, who would have kept the refrigerator in use was 12.0%, and who would have discarded the refrigerator some other way was 83.9%.
- Responses from a survey of 354 non-participant discarders were used to estimate the proportions of discarded refrigerators that would be destroyed or that would be transferred through sale, gift, donation, etc. Based on these data, it was determined that 25.8% of the discarded refrigerators would have been destroyed and 58.1% would have been transferred. At this point, a net-to-gross ratio could be about 0.11+0.581=0.691. However, in the next step of the net-to-gross calculation, another attribution factor of 0.52 is calculated for the discard-transferred category that further reduces this potential net-to-gross ratio.

Table 5 shows the values used to calculate the overall attribution factor for the discarded-transferred category. The data for calculating the percentage distribution were obtained from a survey of 271 recent acquirers of used refrigerators. As can be seen, the calculated attribution factor for refrigerators in the discarded-transferred category is 0.520.

Table 5. *Calculation of Attribution Factor for Refrigerators in Discarded-Transferred Category Using Data from Evaluation of 2004-2005 Statewide RARP*

Main or Spare Unii	*What Would Transferee Do Because Recycling Made Unit Not Available?*	*Percent of Total*	*Attribution Factor*	*Weight x Attribution Factor*
Main	Buy a new unit	44.4%	0.70	0.311
Main	Buy/fix similar used unit	21.4%	0.00	0.000
Main	Buy worse used unit	3.8%	0.00	0.000
Main	Not buy another unit	14.1%	1.00	0.141
Spare	Buy a new unit	3.7%	0.70	0.026
Spare	Buy/fix similar used unit	7.5%	0.00	0.000
Spare	Buy worse used unit	0.8%	0.00	0.000
Spare	Not buy another unit	4.2%	1.00	0.042
Totals		100.0%		0.520

Modifying KEMA Approach to NTG Analysis for Evaluation of California 2004-2005 Statewide RARP

Inspection of Tables 2 and 4 shows that the NTG ratio based on KEMA's approach depends significantly on the attribution factor for the discarded-transferred category. However, there are assumptions in KEMA's approach that are not well supported by data in the 2004-2005 study. In particular, no savings are attributed to discarded-transferred category in cases where a refrigerator captured by the program was replaced by a used refrigerator but would not otherwise been have been removed from the grid. The assumption was that the unit that was replaced and the used unit would use the same or more energy and hence produce no savings.

Implicitly, the second argument assumes that the "used" unit that would be purchased has been off the grid for at least a year and is coming back on the grid "like a new addition to grid" to replace the recycled unit that would have been transferred, and hence the program by recycling a unit did not prevent the recycled unit usage, because another "used" unit came on the grid. This can be illustrated with Table 6. For this example, both the recycled unit that would not be transferred and the unit that would be purchased as its alternative have the same annual energy use, E. For the unit that would be recycled through RARP and not transferred, energy use on grid goes from E to 0 for a savings of E. For the "used" unit that would be purchased, α represents the portion of the previous year that the unit was on the grid and using electricity, E. Because this unit is purchased to replace the unit recycled through RARP, it is assumed that its energy use goes from αE to E, for a negative savings of (α - 1)E. Thus, from the perspective of load on the electric grid, total savings are αE. This implies that there are no savings only if $\alpha = 0$, that is, only if the unit to be purchased had drawn no electricity from the grid for the past year.

Table 6. *Example to Illustrate Calculation of Savings from Purchasing Used Unit to Replace Recycled Unit*

	Energy Use		***Savings***
	Before	***After***	
Unit recycled and not transferred	E	0	E
Unit to be purchased	αE	E	(α -1)E
Totals	E + αE	E	αE

In general, the value of α will depend on the time that elapses between a used unit being removed from the grid and then returning to the grid after being purchased. The overall value of α depends on the mix of sources from which the replacement unit is purchased. The value of α is likely to be high for units purchased from relatives, neighbors, or friends and likely to be lower for units purchased from used appliance dealers. For the situation being addressed here, where RARP has prevented a transfer of a unit, data from the survey of non-participant acquirers of refrigerators and freezers indicated that alternative units are most likely to be purchased from used appliance dealers.

The value of α for units purchased from used appliance dealers will reflect (1) the time that is involved for a dealer to acquire a unit and (2) the time that a unit is on the sales floor before it is purchased. With respect to the first time factor, a survey of used appliance dealers that was conducted for the evaluation of the 2004-2005 RARP indicated that the major sources from which dealers obtain used units (48%) are contracts with appliance dealers (48%), direct pick-up from homes (10%), recovery of a unit as a result of selling a new unit (10%), and auctions (10%). Thus, used appliance dealers have relatively well-established sources that minimize the time they use to acquire used appliances.

The average number of days that a used appliance is on the sales floor before being purchased can be estimated from inventory turnover rates. Data published by The Retail Owners Institute show that the median inventory turnover rate is 5.5 for household appliance stores and 2.0 for used merchandise stores (which includes used appliance stores). An inventory turnover rate of 2.0 implies that an average unit is in inventory (i.e., on the sales floor) for six months before being sold. On these assumptions, the value of α for used appliance dealers would be .50.

Based on this analysis, the attribution factor for "buy/fix similar used unit" for both main and spare units can be changed from 0.00 to 0.50 in Table 5, increasing the attribution factor for the discarded-transferred category from 0.520 to 0.664. Inserting 0.664 into Table 4 (to replace 0.520) raises the estimated NTG ratio from 0.409 to 0.492.

Further, the market data based attribution using "used" acquirer survey data may not be directly applicable without making some adjustment to reflect some semblance to the "recycled" units. Our market data show that a "used" unit that is purchased in lieu of the "recycled" is likely to be more efficient than the unit it is replacing. Used appliances that are acquired are younger than the units being recycled and hence are likely to be more efficient although not as efficient as new units. For cases where a unit of more recent vintage would have been bought, the attribution factor can be computed as the difference in annual energy use (UEC) between the newer vintage used unit and the average unit picked up by the program, expressed as a fraction of the program's average UEC.

Data collected through the surveys of participant discarders and non-participant acquirers were analyzed to determine any difference in ages between discarded/recycled units and acquired units. The average age of discarded/recycled units in the discarded-transferred category was calculated from data in the survey of participant discarders. The average age of acquired used units was calculated from data collected in the survey of non-participant acquirers.

For refrigerators, the average age of units in the discarded-transferred category was 15.6 years. The average age of acquired used units was 6.4 years. According to data published by AHAM, the average energy use of refrigerators manufactured in 1990 was 934 kWh per year; for refrigerators manufactured in 1998 was 680 kWh per year. If energy use is assumed to increase by 0.6% per year, energy use of a six-year old refrigerator in 2004-2005 would be about 70% of the energy use of a sixteen-year old refrigerator. Thus, replacing a refrigerator aged 15.6 years with one aged 6.4 years would result in savings of about 30%.

With $\alpha = .50$ and savings of 30% attributed to replacing an older used refrigerator with a newer used refrigerator, the changes in the calculation of the NTG ratio for the 2004-2005 Statewide RARP are as follows.

- The attribution factor calculated for refrigerators in the discarded-transferred category increases to 0.708.
- The estimated net-to-gross ratio increases to 0.517.

Estimating Free-Ridership for Evaluation of California 2004-2005 RARP

The net impact of an energy efficiency program has usually been considered to be the result of three major factors: free-ridership reduces the net impact while spillover (both participant and non-participant) increases net impacts. The revised protocols for evaluation of energy efficiency programs that the California Public Utilities Commission (CPUC) has recently produced make this distinction clear.[2] With these protocols, the net impact analysis of a program is to focus on free-ridership and participant spillover. Market effects, including non-participant spillover, are to be treated separately and not as part of the net impact analysis.

KEMA's conceptual approach to the net to gross analysis for the RARP does not explicitly separate free-ridership from other effects. For example, recall that refrigerators in the discarded-transferred category are those units whose transfers to other parties were precluded because the units were recycled through RARP and that savings are attributed based on the actions that transferees (i.e., the would-be recipients of the recycled units) would take because they did not receive a recycled unit. However, transferees, who may include relatives, neighbors, friends, charities, used appliance dealers, etc., are by and large not participants in RARP. Thus, their actions are more appropriately analyzed with respect to other non program related market activities and perhaps non-participant spillover if they somehow got influenced by the program and did not purchase another "used" unit – per KEMA method's implicit assumption giving the program an attribution value 1 in such a case. The use of acquirer market data is at best indicating the net market impact of the program, which should at a minimum reflect the relative magnitude of the program vis a vis the "used" units market, which is part of the estimation of market effects and not the estimation of program impacts. In other words, the acquirer survey based adjustment is an exercise in the estimation of market effects and not the estimation of net program savings with respect to participant impacts. The net savings have nothing to do with the wide or narrow option set among hypothetical transfer recipients in the market at large. Hence, any such used market data analysis only implies "net market impact" of the program.

Per the protocols, the goal of a program net impact evaluation is to adjust for savings that would have happened in the absence of the program anyway. In case of RARP, the key issue is the determination of alternative dispositions of the removed working unit that would lead to prevented use of those older, inefficient units in the absence of the program. As with the KEMA approach, there are four categories for what could have happened to a refrigerator or freezer had it not been recycled. Of

[2] The TecMarket Works Team, *California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals.* Prepared for California Public Utilities Commission, April 2006.

these four categories, two are indicative of free-ridership or prevented use of the unit even without the program:

- Refrigerator or freezer would be kept by the household but not used; and
- Refrigerator or freezer would be discarded by the household through a method in which the unit would be destroyed.

Most of the free-ridership rate is determined by the percentage of units that would have been discarded and destroyed even if not recycled through the program. For the evaluation of the 2004-2005 Statewide RARP, questions about the discarding of units were asked in surveys of both participants and non-participants, thereby providing two sets of data with which to estimate the proportion of units that would have been discarded and destroyed.

To estimate the free-ridership percentage for refrigerators recycled through RARP, estimates are needed for (1) the percentage of recycled refrigerators that would have been kept by a household but not used and (2) the percentage of refrigerators that would have been discarded by a household through a method in which the refrigerator would have been destroyed.

Data from a survey of 716 participants in the 2004-2005 Statewide RARP were used to determine the percentage of refrigerators that would have been kept but not used. These percentages are reported by utility and overall in Table 7.

***Table 7**. Percentages of Recycled Primary and Secondary Refrigerators That Would Have Been Kept but Not Used If Not Disposed of Through RARP*

	PG&E	***SCE***	***SDG&E***	***All***
Primary refrigerators	5.50%	3.82%	3.37%	3.96%
Secondary refrigerators	4.05%	3.31%	10.27%	4.34%

Two sets of survey data were available for estimating the percentage of refrigerators that would have been discarded by a household through a method in which the refrigerator would have been destroyed. Responses from a survey of non-participants provided data on how non-participants had actually disposed of refrigerators. Responses from a survey of participants provided data on how participants in RARP would have disposed of a refrigerator recycled through RARP had they not used the program.

Several response categories are directly associated with the destroying of refrigerators even without RARP. For non-participants, these response categories include:

- Took it to a recycler or scrap dealer
- Took it to the landfill or threw it away
- Hired someone to pick it up (for junking or dumping)
- Called utility's appliance recycling program

For participants, the response categories directly associated with destroying the refrigerator include:

- Would have hauled it to the dump yourself
- Would have hauled to a recycling center yourself
- Would have had someone else pick it up for junking or dumping

In both surveys, some respondents indicated that they would have disposed of their old refrigerator through an appliance dealer. However, the evidence developed through the market study showed that large new appliance dealers have largely gotten out of the business of selling used refrigerators and now contract with recyclers to take the units that are removed from households. New appliance dealers also contract with many of these same dealers to take out-of-box and scratch and dented units. Used dealers who sell appliances are primarily interested in clean full-featured units that

are less than 10 years old. Thus, this evidence indicated that some percentage of the refrigerators that would go to dealers would also be destroyed.

An estimate of the percentage of refrigerators sent to dealers that would be destroyed was developed by analyzing survey responses by RARP participants to determine what percentage of units recycled were over 10 years old. That is, only used refrigerators less than 10 years were likely to be sold and remain in use; refrigerators over 10 years old were likely to be destroyed. The analysis of the survey data indicated that about 77.0% of primary refrigerators recycled and about 67.4% of the secondary refrigerators recycled were over 10 years old.

Bringing together the data from the survey responses with the analysis of refrigerators sent to dealers and destroyed, Table 8 shows the estimated percentages of primary and secondary refrigerators that would have been destroyed even without the RARP. Estimates are presented that were derived using data from both the survey of non-participants and the survey of participants. The percentages estimated for primary refrigerators from the two surveys are fairly close, but the percentages estimated for secondary refrigerators show a greater difference.

Table 8. *Percentages of Recycled Primary and Secondary Refrigerators That Would Have Been Destroyed Even If Not Disposed of Through RARP*

	PG&E	***SCE***	***SDG&E***	***All***
Estimated Using Non-Participant Survey Data				
Primary refrigerators	47.8%	39.8%	45.4%	43.6%
Secondary refrigerators	59.5%	41.4%	15.7%	48.9%
Estimated Using Participant Survey Data				
Primary refrigerators	58.0%	36.1%	51.7%	41.7%
Secondary refrigerators	55.5%	29.3%	47.7%	36.2%

The estimates from Table 7 and from Table 8 were used to estimate total free-ridership percentages for primary and secondary refrigerators recycled through the 2004-2005 Statewide RARP by IOUs. These estimates of free-ridership are presented in Table 9. The free-ridership percentages estimated for primary refrigerators from the two surveys are fairly close, but the percentages estimated for secondary refrigerators show a greater difference. Table 10 translates the free-ridership rates into net of free-ridership rates.

Table 9. *Estimates of Refrigerator Free-Ridership for 2004-2005 Statewide RARP*

	PG&E	***SCE***	***SDG&E***	***All***
Estimated Using Non-Participant Survey Data				
Primary refrigerators	48.0%	39.6%	44.2%	43.1%
Secondary refrigerators	49.0%	35.0%	22.0%	41.5%
Estimated Using Participant Survey Data				
Primary refrigerators	57.1%	36.3%	49.9%	41.4%
Secondary refrigerators	46.0%	25.7%	45.7%	31.8%

Table 10. *Estimates of Net-of-Freeridership Rates for Refrigerators for 2004-2005 Statewide RARP*

	PG&E	***SCE***	***SDG&E***	***All***
Estimated Using Non-Participant Survey Data				
Primary refrigerators	52.0%	60.4%	55.8%	56.9%
Secondary refrigerators	51.0%	65.0%	78.0%	58.5%
Estimated Using Participant Survey Data				
Primary refrigerators	42.9%	63.7%	50.1%	58.6%
Secondary refrigerators	54.0%	74.3%	54.3%	68.2%

FINDINGS AND CONCLUSIONS

The analysis presented in this paper is intended to more clearly define the conditions under which energy savings should be credited to RARP, with particular attention given to how this issue was addressed in the method used by KEMA to determine the impacts of RARP in previous years.

A first finding is that applying the estimation method using the larger data sets from the evaluation of the 2004-2005 Statewide RARP gives an estimated NTG ratio (0.409) that is somewhat higher than that estimated in the evaluation of the 2002 Statewide RARP (0.351).

A second finding is that assumptions implicit in the methods used in 2002 that significantly affect the estimates. For example, it was assumed that there are no savings attributable to the program if would-be transferees purchase a used refrigerator. However, our study found that used refrigerators that are available for purchase will be more efficient than the units being recycled through the program, thereby also increasing the NTG ratio. Changing these assumptions results in an increase of the NTG ratio for refrigerators for the 2004-2005 Statewide RARP from 0.409 to 0.517.

The KEMA approach provides a useful taxonomy for categorizing the appliances that are recycled through RARP. These categories are defined by considering what would have happened to an appliance unit recycled through RARP if it had not been recycled. There are essentially four categories for what could have happened to a unit had it not been recycled.

- Of these four categories, two are representative of free-ridership: units that would have been kept by the household but not used; and units that would have been discarded by the household through a method in which the unit would be destroyed. Savings from units falling in these two categories are therefore to be netted out in the analysis of program impacts.
- Savings are to be credited to the program for units that fall into the following two categories: units that would have been kept by the household and still used; and units that would have been discarded by the household through a method in which the unit would be transferred and kept in use.

Using this taxonomy, estimates of free-ridership impacts were developed for both primary and secondary refrigerators and for the program overall and within individual utility service territories.

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